THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

ISSUED BY THE

BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

MAY 1937

WASHINGTON

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BUREAU OF FISHERIES U. S. DEPARTMENT OF COMMERCE

Memorandum I-131 Washington, D. C., May 1937 No. 29

NEW YORK'S FEEDING RECORDS AND HATCHERY PRODUCTION IN 1936

By Charles R. Deuel
Conservation Department, New York

EDITOR'S NOTE

THE SECOND issue of THE PROGRESSIVE FISH CULTURIST carried an article advocating more detailed and complete records of hatchery operations. We are fortunate in being able to present herewith an actual picture of what such records really are and what they accomplish. We are indebted to the New York State Conservation Department for this material.

Charles R. Deuel's report, "New York's Feeding Records and Hatchery Production in 1936" is self-explanatory and reveals information which is of obvious value.

THE PROGRESSIVE FISH CULTURIST would like to publish verbatim the paper on "The New York State Fish Hatchery Feeding Chart," which is presented in abstract form through courtesy of A. V. Tunison. It includes, however, voluminous charts and tables which would strain the mechanical facilities for the makeup of our journal. Undoubtedly, the New York State Conservation Department will make available to those interested a printed copy of the latter report.

THE FOLLOWING report on the feeding charts in New York State hatcheries is the third one but the second covering an entire year. The data were submitted monthly by the fifteen trout hatcheries in the State; all of the fish at these fiftee hatcheries were on record.

Tables 1 to 4 present the average of the data from all the hatcheries for 1936 for brook, brown, rainbow and lake trout, respectively. A minimum of three hatcheries having a species of fish in any size group was again selected for the publication of average values; this of course is the limiting factor as to the size groups for which figures are given for each of the species.

The water temperature was obtained at each hatchery by averaging the morning temperature with the average of the noon and night temperatures. The "pounds of food to produce a pound of fish" is on a wet basis for meat and as purchased for the dry meals. The values for percent mortality and percent increase in body weight are, for the sake of uniformity, always computed as for a 31-day period.

Again, as in 1935, 1/ Tables 1 to 4 indicate an improvement in feeding practices. There is considerably less variation in the maximum and minimum values for "amount of food fed in percent of body weight daily." Also to be noted is a definite reduction in the average amount fed. As might be expected the conversions and food costs per pound of fish gained are in general reduced; and the fact that the percent gains are higher on the average for all species indicate that formerly the fish were being fed at an unnecessarily high rate.

The more general use of substitutts for the expensive meat diets is indicated by the general decrease in the food costs for 1936. This, with a slight lowering in the item "pounds of food per pound of fish gained" caused a material reduction in the food costs for 1936. In fact, it seems apparent that only by careful attention to the amounts fed and the diet can the food costs be kept to the low level of this year.

Table 5 presents a comparison of the results obtained with the four species of trout. As in the previous year the best results were obtained with brook trout, and rainbow, brown and lake trout follow in that order. While browns were again fed at the lowest level there was considerably less variation in these values among the species than last year. The percent gains are higher in each case; but also the percent mortalities are uniformly higher.

Table 6 summarizes the egg production for the year for all of the hatcheries carrying breeders. There was a considerable reduction in the total number of eyed eggs produced, but there was also a definite reduction in the food cost per thousand eyed eggs produced.

The following relationships between the total lengths of trout and the number of trout per pound were used in classifying the data for the table (subject to changes as more data become available).

Size (Inches)	No. Trout per Pound	
	Brown, Brook, Rainbow	Lake
1	2542	4100
2	304	488
3	88.3	134
4	37.8	54
5	19.7	
6	11.6	
7	7.35	
8	4.94	

1/ Annual Report on the Feeding Charts in New York State Hatcheries for the year 1935, Charles R. Deuel, New York State Conservation Department.

TABLE I

BROOK TROUT

Average of Data from all hatcheries - 1936

		Size of Fish in inches: 1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	Avg. of all sizes
Average water temperature	Avg.	46.0	47.3	50.6	51.4	50.6	47.1	43.0	47.3	47.9
	Min.	43.7	44.0	46.9	46.8	45.1	37.0	37.7	46.0	
	Max.	48.0	51.0	54.0	54.8	53.7	55.2	51.0	50.0	
Amount food fed in % body wt.daily	Avg.	7.9	7.6	6.7	5.7	4.1	2.6	1.4	2.5	4.6
	Min.	4.5	4.2	4.0	3.3	1.9	.7	.7	1.1	
	Max.	10.7	11.1	8.9	7.3	4.7	4.9	2.3	3.0	
Lbs. food to produce a lb. of fish	Avg.	4.6	2.9	2.7	2.7	2.6	3.1	3.8	5.0	3.4
	Min.	2.6	1.7	1.3	1.2	1.7	1.1	1.8	2.9	
	Max.	7.5	4.8	4.3	4.3	3.2	4.5	8.6	8.7	
Food cost to produce a lb. of fish	Avg.	.47	.23	.16	.13	.12	.18	.20	.28	.22
	Min.	.14	.10	.07	.06	.09	.10	.09	.15	
	Max.	.82	.39	.20	.22	.15	.30	.36	.59	
Food cost to produce 1000 fish 1"from0" etc.	Avg.	.19	.85	2.31	4.27	7.19	13.57	23.54	43.12	
	Min.	.06	.35	1.42	2.33	4.32	7.87	12.36	22.32	
	Max.	.33	1.34	2.96	6.28	9.93	20.57	38.51	77.67	
Lbs. fish per cu.ft. water, troughs	Avg.	.7	1.4	2.4	3.4	3.3	2.7			
	Min.	.3	.8	1.2	.8	1.5	1.3			
	Max.	1.0	2.3	3.9	5.7	4.8	4.7			
Lbs. fish per cu.ft. water, ponds	Avg.				.2	.5	.6	.8	.9	
	Min.				.2	.4	.3	.1	.3	
	Max.				.3	.8	1.0	1.6	1.3	
Percent mortality by months	Avg.	4.0	2.7	3.4	1.6	3.2	2.2	.4	.1	
	Min.	.5	.3	.1	.09	.02	.01	0	.05	
	Max.	9.9	9.1	6.9	10.0	27.6	18.0	1.7	.2	
Percent increase in body wt. by months	Avg.	94	149	129	108	64	40	17	19	
	Min.	39	93	88	56	31	11	4	8	
	Max.	165	220	177	144	91	91	49	33	

TABLE 2

BROWN TROUT

Average of data from all hatcheries - 1936

		Size of fish in inches:								Avg. of
		1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	all sizes
Average water temperature	Avg.	45.2	49.2	32.9	51.8	48.7	47.3	48.3	49.6	49.1
	Min.	43.2	46.6	50.4	49.7	45.1	45.4	45.3	48.6	
	Max.	46.9	55.8	60.6	56.1	53.6	51.0	51.0	50.4	
Amt. food fed in % body wt. daily	Avg.	4.7	7.1	7.4	4.7	3.3	2.2	2.5	2.5	
	Min.	2.8	4.8	2.9	1.3	1.6	1.7	2.3	1.3	
	Max.	6.1	9.5	11.1	6.1	4.9	2.7	2.7	4.3	
Lbs. food to produce a lb. of fish	Avg.	5.4	5.6	5.3	3.3	3.9	2.7	4.6	2.4	4.2
	Min.	2.3	2.4	2.0	1.3	3.6	2.0	1.7	1.4	
	Max.	8.6	10.0	7.1	5.5	4.5	3.7	8.9	3.9	
Food cost to produce a lb. of fish	Avg.	.46	.38	.27	.14	.18	.14	.25		.26
	Min.	.34	.26	.11	.10	.17	.09	.09		
	Max.	.60	.51	.58	.18	.20	.22	.44		
Food cost to produce 1000 fish 1"from0" etc.	Avg.	.18	1.26	3.45	5.55	9.93	14.89	27.35		
	Min.	.14	.88	1.77	3.28	7.41	11.50	15.99		
	Max.	.28	1.53	6.23	8.95	13.81	21.61	43.54		
Lbs. fish per cu.ft. water, troughs	Avg.	.9	1.5	2.3						
	Min.	.6	.7	1.6						
	Max.	1.4	2.6	3.1						
Lbs. fish per cu.ft. water, ponds	Avg.		.2	.2	.3	.4	.8	.5	.5	
	Min.		.1	.1	.1	.3	.3	.1	.3	
	Max.		.2	.3	.6	.6	2.1	1.1	.7	
Percent mortality by months	Avg.	1.1	3.2	7.6	2.8	2.2	.4	.02	.03	
	Min.	.3	.7	.4	.2	.05	0	0	0	
	Max.	2.0	8.3	33.1	11.8	8.5	.7	.07	.06	
Percent increase in body wt. by months	Avg.	40	71	72	65	32	35	27	35	
	Min.	30	35	60	43	17	15	10	32	
	Max.	48	120	104	125	50	50	42	41	

TABLE 3

RAINBOW TROUT

Average of data from all hatcheries - 1936

		Size of Fish in inches:				Avg. of
		1-2	2-3	3-4	4-5	all sizes
Average water temperature	Avg.	48.9	51.7	51.8	49.8	50.3
	Min.	46.8	47.2	51.0	45.8	
	Max.	50.8	56.0	53.0	53.6	
Amt. food fed in % body wt. daily	Avg.	9.3	7.2	4.1	3.0	
	Min.	6.9	5.3	2.2	1.5	
	Max.	14.3	10.1	6.2	4.2	
Lbs. food to produce a lb. of fish	Avg.	5.3	3.2	3.4	2.7	3.7
	Min.	4.0	1.8	1.5	1.6	
	Max.	6.9	5.5	7.1	3.4	
Food cost to produce a lb. of fish	Avg.	.36	.20	.18	.14	.22
	Min.	.20	.08	.11	.12	
	Max.	.50	.26	.42	.15	
Food cost to produce 1000 fish, 1" from 0" etc.	Avg.	1.17	2.79	5.51	7.72	
	Min.	.65	1.30	2.96	5.88	
	Max.	1.73	3.84	10.18	13.83	
Lbs. fish per cu. ft. water, trough	Avg.	1.2	2.1	2.9		
	Min.	.7	.3	.7		
	Max.	2.1	4.1	3.6		
Lbs. fish per cu. ft. water, ponds	Avg.			.2	.5	
	Min.			.1	.2	
	Max.			.2	.8	
Percent mortality by months	Avg.	10.0	3.4	1.2	.6	
	Min.	1.9	.9	.2	.1	
	Max.	26.2	7.4	3.2	1.1	
Percent increase in body wt. by months	Avg.	103	140	73	40	
	Min.	65	77	22	15	
	Max.	170	300	123	65	

TABLE 4

LAKE TROUT

Average of data from all hatcheries - 1936

		Size of Fish in inches: 1-2	2-3	3-4	Avg. of all sizes
Average water temperature	Avg.	47.8	50.2	47.3	48.4
	Min.	45.4	48.7	46.6	
	Max.	51.0	50.9	48.9	
Amt. food fed in % body wt. daily	Avg.	7.8	7.3	4.4	
	Min.	6.1	5.7	3.2	
	Max.	8.9	8.6	5.5	
Lbs. food to produce a lb. of fish	Avg.	5.4	5.2	9.2	6.6
	Min.	4.5	3.0	7.3	
	Max.	6.1	8.3	11.0	
Food cost to produce a lb. of fish	Avg.	.41	.30	.40	.37
	Min.	.34	.17	.37	
	Max.	.50	.35	.43	
Food cost to produce 1000 fish 1" from 0", etc.	Avg.	.81	2.51	7.46	
	Min.	.68	1.64	6.22	
	Max.	1.00	2.97	8.29	
Lbs. fish per cu. ft. water, troughs	Avg.	1.0	2.2		
	Min.	.8	1.2		
	Max.	1.2	2.9		
Lbs. fish per cu. ft. water, ponds	Avg.			.3	
	Min.			.2	
	Max.			.3	
Percent mortality by months	Avg.	2.2	3.0	.8	
	Min.	.7	.6	.4	
	Max.	5.0	5.6	1.2	
Percent increase in body wt. by months	Avg.	64	76	19	
	Min.	46	70	17	
	Max.	94	85	20	

TABLE 5

A Comparison of the Four Species of Trout

Average of 1-2, 2-3 and 3-4 inch data

	Brook Trout	Brown Trout	Rainbow Trout	Lake Trout
Average water temperature	49.8	51.3	50.8	48.4
Amt. food fed in % body wt. daily	6.7	6.4	6.9	6.5
Lbs. food to produce a lb. of fish	2.8	4.7	4.0	6.6
Food cost to produce lb. of fish	.17	.26	.25	.37
Food cost to produce 1000 fish 1" to 4"	4.27	5.55	5.51	7.46
Lbs. fish per cu. ft. water, troughs	2.4	1.9(1-3)	2.1	1.6(1-3)
Lbs. fish per cu. ft. water, ponds	.2(3-4)	.2	.2(3-4)	.3(3-4)
Percent mortality by months	2.9	4.5	5.5	2.0
Percent increase in body wt. by months	129	69	105	53

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TABLE 6

Egg Production - 1936

Hatchery	Species	Age from egg	Number breeders Sept.30	Food cost 1936	Number eyed eggs	Cost per 1000	Cost per lb. fish gained
Caledonia	Brook	3 yr.	89	$33.05	55,003	.59	.37
Caledonia	Brown	5 yr.	1,050	217.71	494,490	.43	
Caledonia	Rainbow	3 yr.	1,135	247.37	183,920	1.34	.21
Cold Spring Harbor *	Rainbow	3 yr.	481	221.19	69,008	3.20	
Randolph	Brook	4 yr.	29	24.80	21,025	1.18	
Randolph	Brook	2 yr.	627	101.17	357,513	.28	.16
Randolph	Brown	3 yr.	2,496	880.17	1,927,730	.45	.35
Randolph	Brown	6 yr.	409	355.84	1,339,871	.26	

Total food cost for breeders, Caledonia	$498.13
Total eyed egg production, Caledonia	735,413
Average food cost of all eggs, Caledonia	.67 per 1000
Total food cost for breeders, Cold Springs Harbor	$221.19
Total eyed egg production, Cold Springs Harbor	69,008
Aver. food cost of all eggs, Cold Springs Harbor	3.20 per 1000
Total food cost for breeders, Randolph	$1,361.98
Total eyed egg production, Randolph	3,646,139
Aver. food cost for all eggs, Randolph	.37 per 1000
Total food cost for breeders, all hatcheries	$2,081.30
Total eyed egg production, all hatcheries	4,450,560
Aver. food cost all eggs, all hatcheries	.46 per 1000

* Food cost for Jan.-Feb.-Mar. estimated

Production of Trout in New York State Hatcheries - 1935 and 1936.

The figures in tables 7 and 8 were obtained from the feeding charts of the calendar years 1935 and 1936, which present primarily a summary of production for the two years with comparisons. The values will not correspond to those found in the Annual Reports of the Conservation Department since these values are based on the calendar year as are the Annual Reports on the feeding charts, while the Conservation Department Annual Reports are based on the fiscal year from July 1st to June 30th.

You will note that figures are given for the weight of fish shipped and also for the total weight produced. The weight of fish shipped during a year obviously does not give the whole story due to differences in weight on hand at the end of the year. You may note that in 1935 the hatcheries had over 15,000 lbs. less trout on hand on December 31st than on the December 31st of the preceding year. In 1936, however, there were over 19,000 lbs. more on hand than on December 31st of 1935. This means mainly that more fish are being carried over the winter to put out as legal-sized fish next spring.

Also taken into account were the fish shipped into the rearing stations in the spring; that is, the weight of any fish received was subtracted from the fish shipped to obtain the real weight produced.

It must be borne in mind that as far as production values are concerned the data are not complete for 1935; no figures are available for the Adirondack and Cold Spring Harbor Hatcheries since the charts were not being used in those hatcheries that year; no figures are given for Lily Lake because of a flood during the summer which caused the loss of practically the entire stock of fish. The same will apply to the pounds and cost of food used in the State for that year. The values for the conversion and cost per pound of trout produced will of course not be affected.

It will be noted that even with no figures from three hatcheries the weight of fish shipped in 1935 was greater than in 1936; however, the actual production was considerably less than in 1936. In 1935, 116,996 pounds of trout were produced with 494,068 pounds of food costing $33,553.97. In 1936, 141,022 pounds of fish were raised with 488,327 pounds of food costing $26,902.19. The average cost per pound of the food used in 1935 was $0.068; in 1936 it was $0.055. This is a 19.2 percent reduction in the cost of the food per pound. As you all know, this was not due to any drop in feed prices; quite the contrary was the case. It represents rather the use of less of the expensive meat diets and the greater use of dry feed materials and of fresh fish in the diet.

It should be pointed out that the above costs represent the actual expenditures for food. When figures are given for an individual lot of fish, as is done in the annual report on the charts, the food costs are based on the amount of food weighed out and fed to that lot. This does not represent quite the true picture because of the waste of meat. But in these tables the actual amount of meat purchased is charged up to each hatchery.

The most encouraging feature to be noted is the difference in the pounds of food to produce a pound of fish and the food cost per pound of fish produced for the two years. In 1935 it required 4.22 pounds of food to produce a pound of trout and the average pound of trout cost $0.285. In 1936 it required on the average only 3.46 pounds of food to produce a pound of trout and the food cost per pound was $0.1905. We feel sure that at least part of this reduction in food costs can be attributed to the greater attention given to feeding due to the use of the feeding charts, and especially to the elimination of the overfeeding that was somewhat prevalent in 1935 and former years.

We should be very interested in obtaining data from hatcheries in other states. It was partly with this in mind that Mr. Haskell, Mr. Tunison and the writer have written up in detail a paper entitled "The New York State Hatchery Feeding Chart - Its Purpose and Mechanics of Operation." In this paper are presented all of the different forms that are used in assembling and summarizing the hatchery data and the different methods used in obtaining the values of such items as the amount of food fed in percent of body weight daily, the percent mortality and the percent gain. We feel confident that other states adopting the use of the charts will find that they are well worth the effort involved.

TABLE 7

PRODUCTION IN NEW YORK HATCHERIES

January 1, 1935 - December 31, 1935.

Hatchery	Wt. of fish shipped	Difference Dec. 31	Total wt. produced	Lbs. food	Cost of food	Conv.	Cost per Lb.
Bath	5,532	Minus 1,319	4,213	23,497	1,842.28	5.6	.44
Caledonia	9,260	Plus 68	9,328	73,625	5,392.96	7.85	.57
Cambridge	4,008	Minus 290	3,718	10,573	796.33	2.85	.21
Chateaugay	10,220	Minus 4,488	5,732	32,899	2,622.93	5.75	.46
Crown Point	10,904	Minus 832	10,072	33,560	2,295.86	3.30	.23
Johnstown	4,825	Minus 725	4,100	13,570	907.82	3.30	.22
Lake George	6,419	Minus 294	6,125	30,317	1,900.03	4.95	.31
Randolph	34,363	Minus 6,782	27,581	116,598	7,546.22	4.20	.27
Rome	27,515	Minus 596	26,919	93,256	5,715.05	3.45	.21
Summitville	2,305	Minus 282	2,023	6,576	558.31	3.25	.275
Warrenburg	6,051	Plus 433	6,484	17,606	1,123.80	2.70	.17
VanHornesville	10,948	Minus 247	10,701	41,991	2,852.38	4.65	.265
Total	132,350	Minus15,354	116,996	494,068	33,553.97	4.22	.286

Average cost per Lb. of Food = .068

TABLE 8

PRODUCTION IN NEW YORK HATCHERIES

January 1, 1936 - December 31, 1936.

Hatchery	Wt. of fish shipped	Difference Dec. 31	Total wt. Production	Lbs. food	Cost of food	Conv.	Cost per Lb.
Adirondack	988	Minus 500	488	3,121	191.51	6.4	.39
Bath	6,481	Plus 1,645	8,126	24,496	1,334.82	3.0	.164
Caledonia	8,084	Minus 5,434	2,650	34,327	2,019.77	12.9	.76
Cambridge	3,482	Minus 205	3,257	7,520	442.05	2.3	.136
Chateaugay	12,157	Plus 328	15,432	37,806	2,244.08	2.45	.145
Cold Spring Harbor	4,138	Plus 58	4,196	29,377	1,391.29	7.0	.33
Crown Point	7,559	Plus 461	8,020	23,662	1,952.04	2.95	.24
Johnstown	5,875	Plus 880	6,755	27,412	1,449.46	4.0r	.21
Lake George	8,107	Plus 1,135	9,242	39,065	2,050.95	4.23	.22
Lily Lake	3,852	Minus 318	3,534	13,847	848.79	3.88	.24
Randolph	12,421	Plus 6,597	19,018	68,357	3,669.00	3.6	.193
Rome	31,623	Plus 1,187	43,494	122,674	6,301.62	2.8	.145
Summitville	3,134	Minus 194	2,940	8,829	443.75	3.0	.15
Warrensburg	6,921	Minus 227	6,694	17,109	930.14	2.56	.14
Van Hornesville	6,923	Plus 253	7,176	30,725	1,662.83	4.3	.23
Total	121,719	Plus 19,303	141,022	488,327	26,902.19	2.46	.1905

Average cost per lb. of Food = .055

THE NEW YORK STATE FISH HATCHERY FEEDING CHART ITS PURPOSES AND MECHANICS OF OPERATION

By Charles R. Deuell, David C. Haskell and A. V. Tunison

Conservation Department, Albany, N. Y.

THIS REPORT covers the methods employed in computations used in the Feeding Chart in the New York State Hatcheries. Formulas used to calculate percent gains, percent mortality, and amount of food fed in percent of body weight of fish are presented with cases of irregularities such as fish shipments and high mortality included. Methods used to determine food conversion, food cost of production, denseness of fish population, etc., are explained in detail.

Included are charts showing the various forms used in conjunction with the system.

The present report shows the progress made since the inauguration of the Feeding Chart and is more in detail than the earlier report (Deull, C. R., A Study of the Food Cost of Trout in New York State Hatcheries, Trans. Amer. Fish. Soc., Vol. 64, p. 172, 1934).

Since various tables are employed in the use of the Feeding Chart an appendix is included giving "Tables Applicable to Hatchery Operations". These include: Table 1a-1d, The amount of food to feed the four most common species of trout per day in percent of the body weight and for different size groups held in water of different temperatures; Table 2, The increase in the daily weight of fish during a period of one month when the rate of growth is known; Table 3, Relationship among amount of food fed daily, growth, and conversion; Table 4, Time required to produce one-half inch of growth for various sizes of trout when the rate of growth is known; Table 5, The relationship between the total lengths of trout and the number of trout per pound; and, Table 6, Equivalent percentage gains for daily intervals. With the exception of Tables 5 and 6, the above tables were previously published (Tunison, A. V. Tables Applicable to Hatchery Operations, Fish Culture, Vol. 2, No. 5, May 1936, N. Y. State Cons. Dept.).

A. V. Tunison

A NEW AND SUCCESSFUL METHOD OF SEALING FISH PONDS

By Alvin R. Cahn, Biological Readjustment Unit, Forestry Division, TVA

THE NEW FISH hatchery, operated by the Bureau of Fisheries in cooperation with the Tennessee Valley Authority, is located just below Norris Dam on the banks of the Clinch River at Norris, Tennessee. This hatchery consists of three two-acre ponds, which were constructed for the most part by CCC boys with the assistance of a certain amount of skilled labor. They were excavated in a sandy loam soil and are four feet deep in the center, with a large amount of shallow water and feather edge. On completion these ponds were flooded one by one, and to our consternation it was found that the seepage loss approximated half the total capacity of the 1600 G.P.M. pump. The result was that the pumps had to be kept running day and night to maintain a constant level once the ponds were filled; one pond in particular dropped 7½ inches over night when the pumps were shut off. Forty-three new springs appeared in the river bank below the hatchery following the filling of the ponds, and how many more came up in the river or down stream farther than we searched there is no means of knowing. It was hoped that in time this seepage loss would decrease, but after two months it was found that there was no let-up discernible. Obviously something had to be done and done quickly if we were going to have any bass breeding in the ponds this spring, for the river water was so very cold (48°) that constant pumping would prevent breeding. Seeing that we had a real problem on our hands, we decided to try Vololay Bentonite as a possible solution.

This material, a product of the American Colloid Company of Chicago, is a volcanic clay, mined in South Dakota. In appearance it resembles very closely white corn meal or a fine white sand. It has the property of being highly hygroscopic: when in contact with water, it takes up water and swells to fifteen times its bulk, yet in so doing exerts no pressure. Thus, if mixed with soil and moistened, it swells up and conforms to the many tiny cavities in the soil, forming a watertight seal. A description of the method of application follows:

The ponds, which were already full, were drained and allowed to dry sufficiently to be plowable. They were then plowed to a depth of 8 inches by an ordinary farm turning plow. After this plowing, the pond bottoms were rolled with a sheeps-foot roller in 18 inch laps, so that each square foot received about three rollings. The rolling operation was followed by a drag, to take out the surface irregularities of the bottom. Pond No. 1 was then staked out in 20-foot squares, and one bag (100 pounds) of No. 80 KWK Vololay was applied to each square (400 square feet of surface). Ponds No. 2 and No. 3 were staked 20 x 25 feet, and one bag was used to cover this 500 square feet, the reason being that Pond No. 1 was seeping more than either of the others and hence received a slightly heavier treatment. No machinery was at hand to do the spreading, so we used a crew of CCC boys who scattered the Bentonite by hand square by square. Since there was a considerable dust cloud stirred up, I made the boys wear cheese cloth masks as a protection against inhaling Bentonite into their lungs, for I am not at all certain just what a few good lung-fulls of this material

might do, and preferred to take no chances. As the Bentonite was spread square by square, a second crew of CCC boys hand-raked it thoroughly into the upper inch and a half of the soil, this crew following on the heels of the spreaders. When the entire pond had been thus raked, the bottom was again rolled with the sheeps-foot roller until the "feet" no longer sank into the dirt. It was then dragged once more to finish and smooth the surface. The pond was then flooded.

Preliminary experiments by Dr. M. M. Ellis of the Bureau of Fisheries indicated that this Bentonite was slightly toxic to fish, but that if the first water was permitted to stand for a couple of days and then run off and the pond refilled, all toxic substances were definitely removed. Therefore, once filled, we permitted the pond to stand for two days, then drained it, completely refilled it and put in our brood stock of large-mouth bass. After the bottom of the pond was prepared and ready for the Bentonite application, the spreading, raking and at least part of the rolling was completed in one day. The following table indicates the results obtained:

Pond No.	Loss before treatment: G.P.M.	Loss after treatment: G.P.M.
1	350	56
2	270	32
3	167	17

These losses are computed without taking into consideration the evaporation factor, which is a much higher percent of the total loss after treatment than before. No attempt was made to treat the dikes. The depth of the ponds varies uniformly from 18 inches around the edges to four feet at the outlet.

The treatment was completed only two weeks prior to the spawning of the bass, and it is gratifying to note that at this writing (May 17) there are some 88 bass nests occupied, and around 200,000 newly hatched fry in the ponds, indicating: (1) that the Bentonite as used has had no injurious effects upon the eggs even though they were in some cases laid directly on the material; and (2) it has had no injurious effect upon the newly hatched fry. It is also to be noted that plantings of various aquatic plants have taken hold in fine style and are growing well, even though their roots must be in contact with Bentonite.

It is gratifying to be able to make this report, for it is believed that this material will find a most useful place where problems of seepage are encountered in fish ponds.

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MORTALITY OF HATCHERY TROUT, GREAT SMOKY MOUNTAINS NATIONAL PARK

By Willis King, Assistant Wildlife Technician

National Park Service

A NEW TROUT hatchery was built in the Great Smoky Mountains National Park by the U. S. Bureau of Fisheries during 1936. Standard concrete rearing pools were built by the National Park Service, at the same place and time. Some of the pools were ready for use by April 1, while the hatchery itself was not completed until later in the year.

High mortality was experienced among rainbow trout fingerlings brought from several hatcheries outside the Park. Practically all losses occurred within three days after the arrival of the fish, and were most severe twelve to twenty hours after they were put in the rearing pools. Mortality was as high as 90% in some cases. This paper deals with the problem encountered at Kephart Prong and points toward the cause and possible solutions of the difficulty. It is felt that a resume of the situation and experiments tried might be of value in dealing with a similar problem elsewhere.

The first consignment of fish, some 48,000 rainbow trout, arrived at the Park early in the morning of April 13, from the Wytheville (Va.) hatchery. These fish were approximately 1½ inches in length and appeared to be in good condition. They were placed in four of the new circular rearing pools, each of which is of an approved type 25 feet in diameter. Food was provided about an hour after the fish were placed in the pools and again at 5:00 PM. Shortly after the second feeding many of the fish went into convulsions, and finally died on the bottom of the pool. By morning not more than 8,000 of the lot were living. Part of these continued to die for about three days, after which time some 6,000 survivors thrived and grew to planting size.

Naturally an effort was made to discover the cause of the disaster. A close examination of the meat fed, which was Government inspected frozen sheep liver, failed to show any trace of spoiled or tainted meat. Two of the pools had been completed more than six weeks, while the other two had been finished only about two weeks. Although the losses were not the same in all the pools, there was no relation between the age of the pool and the number of fish killed. All the pools had been scrubbed, filled and drained several times, and had been allowed to dry in the sun between fillings. No evidence was found which indicated that the loss was due to any poisonous substance from the new concrete.

In order to check on the Wytheville trout, trout were brought from the North Carolina State Hatcheries at Marion and at Balsam Gap near Waynesville; and from the Erwin, Tennessee Hatchery. The fish from Marion suffered at least a 75% loss. However, some 12,000 of the same lot taken to the rearing pools at the Chimneys Camp

Ground in Tennessee, a distance of not more than twelve miles from Kephart Prong, thrived nicely. After several weeks five hundred of these trout were brought back to Kephart Prong and put in one of the rearing pools. Within twelve hours they began to die, and to save the lot they were taken to a nearby stream and released. Trout from the Erwin Hatchery placed in freshly made dirt pools on Collins Creek, two miles below Kephart Prong, thrived, while some of the same lot of fish, placed in the concrete pools at Kephart Prong, died as did those from elsewhere. The Balsam Mountain State Hatchery derives its water supply from the same general rock formation as does the Kephart Prong Hatchery. Fish from Balsam Mountain suffered less than did those from other sources, and not over 50% died upon introduction into our rearing pools.

In all cases, the fish were introduced in the morning and began dying about dark of the same day. The heaviest losses occurred between this time and the following morning. Some continued to die for about three days, after which time the survivors thrived with no more than normal losses. Rainbow trout from 1½ to 3 inches in length were used.

As in the first case mentioned, the kind of food given the fish could not be considered a factor in the losses. Beef liver, beef heart, and sheep liver were fed at different times. Starving the fish for six, twelve or twenty-four hours after their arrival had no effect on their survival.

Temperature changes experienced by the fish upon introduction into the rearing pools were not over 10 degrees Fahrenheit. The temperature of the water in the rearing pools never exceeded 66 degrees during this part of the summer.

The amount of water permitted to flow through each pool varied from less than five gallons to more than thirty gallons per minute. No effect on the condition of the fish could be found by changing the volume of flow. In later experiments certain pools were filled as much as twelve hours before introducing the trout. Mortality in these cases was not as great as when the fish were put in freshly filled pools. In other cases the fish were put in pools with only a small amount of water, and the pools filled at different rates. No effect on mortality could be noted when the pools were filled in two, six or twelve hours time. Allowing the water to enter the pool through a number of small openings or by forcing it through a screen did not lessen the effect on the fish.

The pools lie on a south-southwest exposure and catch the direct rays of the sun. It was suggested that since the small trout came from dark hatchery troughs, kept indoors, that the bright sunlight might be affecting them. Shelters made of old canvas were hastily constructed on one occasion. The fish responded positively to the shade afforded by these shelters, but even this did not stop their dying.

It was discovered by Mr. E. J. Rosser, CCC Camp Superintendent, that if trout, when first brought to Kephart Prong, were put in a wire box in the stream which supplies water for the hatchery and rearing pools, they survived. This bore out previous suppositions that the disturbing factor lay in the pipeline. The stream itself supports a good population of rainbow trout. To test this further, five hatchery troughs with their fish, were brought from Wytheville to Kephart Prong. Four of these were installed in the new hatchery building and supplied with water from the same

pipeline and source as that furnishing the rearing pools. One trough was set up outdoors along the stream and fed directly from it. Almost all the rrout kept in the hatchery died, most of them within twenty-four hours. Not over 1% of those put in the trough by the stream died during the same period, or soon thereafter.

Trout put in a rearing pool to which water was fed by a wooden flume, direct from the creek, went through the three day period with no more than the normal losses. Some of the same lot of fish, put in the next rearing pool whose water supply came through the regular pipeline, succumbed as did others before them. The pipeline in question carries water from a concrete dam at Kephart Prong, approximately 1,000 feet to the hatchery and rearing pools. It is ten inches in diameter and made of spiral welded steel, galvanized on the inside.

A few weeks later, some 15,000 rainbow fingerlings were acclimated in the pool fed by the wooden flume. After a week water was gradually added from the regular pipeline, and by another week the flume was abandoned. No losses occurred during the change.

Believing there might be some chemical substance responsible for the death of the fish, samples of water were collected and taken to Dr. G. A. Shuey, Agricultural Chemist at the University of Tennessee, April 22. Dr. Shuey was kind enough to run a preliminary analysis on the samples. His report states: "I have examined the water samples and find nothing that would be detrimental to fish. The water from pool B has a pH value of 6.92 and contains 62 parts per million of solids. The creek water has a pH value of 6.86 and contains 56 parts per million of solids,

"The solids are not present in excessive amounts, and are composed of calcium and magnesium salts for the most part. There are traces of iron, aluminum, phosphorus and silica, in the form of salts, present. There is also a small amount of organic matter present. Tests for arsenic and lead were negative.

"The above was merely a qualitative examination. There appears to be nothing wrong with the water chemically"

Samples were taken to Dr. Edwin B. Powers, of the Zoology Department, University of Tennessee, at the same time. Dr. Powers and his assistants made the following report:

"Oxygen, co per liter

unaerated sample as taken from pools.....6.13
aerated sample as taken from pools.....6.16
unaerated sample, after standing 24 hours.....5.42
aerated sample, after standing 24 hours.....6.008

Hydrogen ion concentration

water sample from pool, unaerated.....7.3
water sample from pool, unaerated, same after 24 hours.....6.72
water sample from pool, aerated.....7.42
water sample from pool, aerated, same after 24 hours.....6.7
bacterial content, creek water, negligible.

Bacterial content, in pools where fish died, approximately 100 times greater. Species not determined". The difference in hydrogen-ion concentration reported by Dr. Shuey and Dr. Powers as due to the several days that elapsed between the time the samples were taken and when they were tested in the former case. Different technique was also employed.

A more complete qualitative analysis was made by the Water Analysis Laboratories of the U. S. Geological Survey. Miss Margaret D. Foster reported the following findings on the water samples collected by me July 31.

	Stream	Rearing Pools
"Silica (SiO_2)	5.8	5.8
Iron (Fe)	.004	.006
Zinc (Zn)	.06	.06
Copper (Cu)	(a)	(a)
Lead (Pb)	(a)	(a)
Calcium (ca)	1.2	1.3
Magnesium (Mg)	.6	.6
Sodium (Na)	.9	1.0
Potassium (K)	.5	.5
Carbonate (CO_3)	0	0
Bicarbonate (HCO_3)	5.0	6.0
Sulphate (SO_4)	1.7	1.8
Chloride (Cl)	.5	.3
Fluoride (F)	.2	.1
Nitrate (NO_3)	.44	.52
Total dissolved solids	16	16
Total hardness as $CaCo_3$	5.5	5.7

(a) Less than 0.1 part".

This analysis failed to show any appreciable difference in chemical content of the water taken from the rearing pools and the stream. All analyses seem to indicate that there is nothing fundamentally wrong with the water, and that the fish were not poisoned by any injurious substance. Dr. Powers made further studies at the hatchery May 16, and expects to do more work on the same general problem. His preliminary findings seem to indicate a state of gaseous unbalance, principally abnormal carbon dioxide tensions. Whether this condition was caused by the pipeline, the new concrete pools, or is a peculiar property of that particular stream could not be determined without further experimental work. Dr. Powers plans to publish his findings, so they will be available at a later date.

A consignment of approximately 30,000 rainbow trout eggs from Idaho was received by the Kephart Prong Hatchery in June. The eggs suffered from their long trip, but hatched very well considerng the season and the relatively high temperatures which prevailed here during their hatching period. These fish were later transferred to one of the regular outdoor pools, where they grew very well. No serious losses occurred in the lot. This gave evidence that trout hatched in the Kephart Prong Hatchery are adapted to any peculiar properties of the water and will thrive.

The exact cause of the difficulty yet remains to be found, but it is apparently a physical or chemical change in the water, which occurs either in the pipeline or in the pools. It would have been interesting to determine the possible effect on brook trout, but none were available for experimental purposes.

EXPERIMENTS IN POND REARING OF TROUT ON NATURAL FOODS

By P. R. Needham, U. S. Bureau of Fisheries
and R. C. Lewis, California Division of Fish and Game

SINCE 1932, a part of the regular research program of the California Trout Investigations* has been that of rearing trout in ponds on natural foods alone. This work has all been done at the Hot Creek Experimental Station in eastern California. The results of four seasons' work there may prove of interest to the readers of the P.F.C. in pointing out in a general way, some of the difficulties involved when rearing trout in this manner and in showing the survival rates obtained after varying intervals of time from given numbers and species planted.

The Hot Creek ponds, in which the experiments under discussion were carried on, lie at an elevation of 7,000 ft. on the east slope of the Sierra Nevada Mts. in the Owens River Valley, thirty-eight miles north of Bishop, California. The water supply is entirely from springs that flow from beneath volcanic rock outcrops. The springs are entirely protected from floods as the entire drainage basin is only some 75 acres in extent and no flood waters enter the area. Over twenty separate springs, varying in temperature from 52° F. to 68° F., supply three separate spring-runs that contain luxuriant growths of watercress and other aquatic plants. The latter is inhabited by vast numbers of shrimp (Gammarus Limnaeus), mayfly nymphs, caddicefly larvae and pupae, snails and other organisms. Over one-quarter of a pound of pure shrimp containing 5,063 individuals was taken from an area of one square foot in the center of a watercress bed in Pond No. 1 in 1934. It was to take advantage of the enormous supply of fish foods present at Hot Creek that these experiments were started in 1932.

The combined flow of the three runs totals over thirty second-feet of water. All rearing ponds were built on the upper or No. 3 run by throwing dirt-fill dams with plank retaining walls across this run. The water supply for all the ponds is from head-springs which flow only about three hundred feet before entering the first or Pond No. 1. The temperature of the water as it leaves the ground is 63° F. the year round. A dirt-fill-plank diversion dam with two inlet flumes was built at the upper end of what was planned as Pond No. 1 at the start of construction work. By the use of flashboards in the flumes of this dam, water can either be diverted around the rearing ponds below through an old irrigation ditch, or allowed to flow through the ponds themselves. Ponds Nos. 1 and 2 were built in the fall of 1931 while Nos. 3 and 4 were built in the summer of 1934. The following tabulation gives the size of the four ponds concerned:

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*These investigations have been conducted jointly between the U.S. Bureau of Fisheries and the California Division of Fish and Game since 1932. The writers wish to thank officials and workers in both agencies for much help given from time to time in the progress of this work.

	Area in square feet	Length ft.	Width ft.
Pond No. 1*	12,871	211	61
" No. 2.....	8,600	200	43
" No. 3.....	20,930	455	46
" No. 4.....	7,315	133	55

*In 1934 Pond No. 1 was broken up into two ponds now called Nos. 1 and 2. Thus former pond No. 2 was renumbered No. 3 and No. 4 was constructed below this pond.

The slope of the pond bottoms is very gradual averaging about one foot in 110 feet. The water depth at the dams was usually maintained between twelve and eighteen inches. It was necessary to keep the water fairly shallow at the dams due to the fact that water deeper than this usually caused the watercress beds near the dam to float free from the bottom after which they would be carried down against the screens clogging them. In all the ponds the only place pools as such existed was close to the dams themselves. The upper ends of all the ponds were really riffle areas. Two main channels through the watercress were kept open the entire length of each pond and lateral channels were made in the cress at the sides to permit trout to get into various parts of the pond to feed and also to allow the shrimp a chance to work out of the cress into open water where the trout could get them.

Single stationary screens set at about 45° angles were used in each of the two outlet or inlet flumes in each dam. Heavy galvanized wire cloth having eight meshes to the inch was used. The largest item of labor was cleaning these at intervals each day the ponds were operated. Thick growths of algae formed in the ponds ahead of the dams during sunny periods and often made it necessary to clean them five or six times a day. Under normal conditions however four times a day was sufficient to keep them open and a good supply of water passing through the ponds. The use of rotary self cleaning screens might be advisable, but cost of construction prohibits their use at present.

Preparing Ponds for Stocking

It required considerable effort each season to prepare the ponds for stocking. The Hot Creek runs had been stocked for years with both rainbow and Lock Leven trout and large numbers of these fish naturally had to be removed from the pond areas prior to planting the small fish to prevent cannibalism. In June, 1936, about 600 trout ranging in size from four to seventeen inches were removed. Lower Hot Creek about half a mile below the ponds is open to angling and is a famous fishing stream of eastern California. Hence considerable numbers of trout constantly work up into the pond areas when the screens are removed after draining. It would require too much effort to keep screens in the inlets and outlets of the ponds when not operated due to the labor involved in keeping them clean.

Draining Ponds

At the end of any operating period it was necessary to remove all the watercress from the ponds in order to net out the fish. This likewise involves considerable labor, though once the ponds are drawn down most of the fish congregate in the pools in front of the dams. The rapidity with which watercress will grow back into a pond bottom following its removal is surprising. In 1936 three days after the cress had been removed the small, bright green, germinating plantlets could already be seen starting to grow. It usually requires about three months for the watercress to grow back to its original density after any given operation period.

After the cress is well started again shrimp taken from the cress beds in others runs are restocked in the ponds to assist in replenishment of food. It has been quite evident when removing the cress prior to netting that the trout planted usually had not completely decimated the foods except in one instance. After draining the ponds in May 1935 when the ponds were operated over the winter for nine months, a paucity of foods was evident in all four ponds. Evidently heavy stocking coupled with operation over a long period, caused depletion of the food supply.

Results in 1932 and 1933

In Table 1 below are given the complete results to date. In 1932 and 1933 the most significant observation is that a survival of approximately 40 percent was obtained after draining the ponds both seasons regardless of the widely varying numbers planted in the ponds these two years. For instance, in 1932 there were 3.56 of sq. ft. of pond surface area available per fish in Pond No. 1 and a survival of 43.26% was obtained after 2.7 months operation. By way of contrast, in 1933 in the same pond, only 0.72 sq. ft. were available per fish due to over four times as heavy stocking and yet a survival of 45.22% was obtained after 3.5 months; almost a month longer operating period than in 1932 and yet a higher survival was obtained. The only noticeale difference between these two lots of fish was the rate of growth per month, the rainbows averaging 0.63 inches per month in 1932 and the Loch Leven, 0.48 inches per month in 1933. The logical conclusion from these observations is that the 29,748 loch leven trout planted in 1933 was somewhat in excess of the available food supply, which resulted in slower growth per month. This is evident with both lots of fish planted in 1933, for the average growth in 1932 for both lots was 0.63 inches and in 1933, 9.46 inches. It should also be stated that this difference in growth rate may have been partly due to the inherent capacity of each species for growth. It is generally believed by fish culturists that loch leven are slower growing than rainbows when young. An average growth of approximately half an inch a month was demonstrated in water at 63° F. in 1932 and 1933.

As shown by Leo Erkkila's article in the P.F.C., July 1936, No.20, p. 10 it is interesting to note by way of comparison that on an artificial meat and meal diet using concrete raceways on water at the same temperature (63°F) a growth of almost an inch a month (0.99 in.) was obtained at Hot Creek using rainbow trout that averaged 5.1 inches in length at the start of this experiment. Feeding a diet of pure shrimp under exactly the same conditions, Erkkila obtained a growth rate of 0.82 inches per month. These comparisons clearly indicate the greater growth rates possible when the element of competition for food is eliminated.

Table 1. Hot Creek Rearing Pond

Experiments, 1932 to 1936

Year	Pond No.	Species	Number Planted	Date	No. Recovered	Time Interval	Per cent Survival	Stocking Rate sq. ft. available per fish	Ave. Length in inches* At Planting	Ave. Length in inches* at Draining	Ave. Growth in. per month
1932	1	Rainbow	6,031	July 8	2,609	2.7 mo.	43.26	3.56	1.2	2.9	0.63
1932	2	Rainbow	3,042	July 8	1,188	2.7 mo.	39.05	6.88	1.2	2.9	0.63
1933	1	Loch Leven	29,748	June 15	13,451	3.5 mo.	45.22	0.72	1.3	3.0	0.48
1933	2	Loch Leven	19,832	June 15	8,311	3.5 mo.	41.91	1.06	1.3	2.9	0.45
1934-35	1	Rainbow	8,154	Aug. 4	4,074	9.1 mo.	49.96	1.58	1.98	5.1	0.34
1934-35	2	Rainbow	10,995	Aug. 2	686	9.1 mo.	6,24	0.78	2.08	7.0	0.54
1934-35	3	Eastern Brook	19,046	Aug. 2	3,968	9.1 mo.	20.83	1.10	2.53	5.08	0.28
1934-35	4	Rainbow	7,068	Aug. 8	1,045	8.7 mo.	14.78	1.03	3.03	5.41	0.27
1936	1	Loch Leven	12,871	June 25	9,207	3.3 mo.	71.53	1.0	1.59	3.15	0.47
1936	2	Loch Leven	8,600	June 26	6,396	3.1 mo.	74.37	1.0	1.62	3.21	0.51
1936	3	Loch Leven	20,930	June 25	15,591	3.1 mo.	74.49	1.0	1.41	2.76	0.43
1936	4	Loch Leven	7,315	June 26	4,726	3.0 mo.	64.61	1.0	1.45	2.69	0.41

* Total lengths only are submitted here; from the tip of the lower jaw to the fork of the tail.

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Results, 1934-35

In 1934 the four ponds then available were stocked in early August and operated over the winter for the first time until May, 1935, for approximately a nine months period. The fish planted were intended for later egg-taking at Hot Creek.

Widely varying survival and growth rates were obtained during this period as shown in Table 1. Surprisingly enough Pond No. 1 showed a survival of almost fifty percent which was higher than any obtained in 1932 and 1933 and in spite of the fact that the pond was operated over three times as long a period. It might be argued that the higher survival obtained in 1934-35 in Pond No. 1 was due to the fact that the fish averaged over half an inch longer at planting as compared to 1932 or 1933. True they did, but in Pond No. 2 in 1934-35 a survival of only 6.24% was obtained and these fish averaged better than seven-tenths of an inch longer than those planted in 1932 and 1933 yet the lowest survival rate of all resulted. Ponds No. 3 and No. 4 in 1934-35 showed survivals of 20.83% and 14.78% respectively.

A comparison of the average growth rates obtained per month in 1934-35 with those of 1932 and 1933, shows in most cases much slower growth over the nine months period. One outstanding exception was the fish in Pond No. 2. These fish averaged better than half an inch a month (0.54 in.) and made the greatest total growth. They averaged 2.08 inches at planting and exactly 7.0 inches after draining the pond. As noted above however, the fish in this pond showed the lowest survival rate obtained of only 6.24%. Whether or not rapid growth of these fish was due to the cannibalistic habit of eating their smaller brothers and sisters was not determined but this factor coupled with losses due to predators and other causes, undoubtedly played a definite, but highly unmeasurable part, in bringing about the lowest survival obtained.

Results of 1936

In 1936 when the ponds were again operated only in the summertime for approximately a three months period using Loch Leven trout, survival rates varied from a low of 64.61% in Pond No. 4 to a high of 74.37% in Pond No. 2. Compared to an average survival rate of only slightly over 40% for the years of 1932 and 1933, the average of over 72% obtained in 1936 was decided improvement.

Although it is not indicated in Table 1, in 1936 the 8,600 fish planted in Pond No. 2 were fish that had been graded out by using a fish grader from a lot of fish that ran approximately 39.5 to the ounce. After grading, the larger fish that did not pass through the grader averaged slightly better than 33 to the ounce and averaged 1.62 inches in length. Fish that passed through the grader, or in other words the runts, averaged 1.45 inches in length (52 per ounce) and were planted in Pond No. 4. As a matter of comparison it might be well to point out that the fish in Pond No. 1 are the same fish that were graded for planting in Ponds 2 and 4. In Table 1 it is shown that the selects planted in Pond No. 2 averaged 0.51 inches growth per month while the runts averaged only 0.41 inches per month in Pond No. 4. It is evident from these figures that the larger, faster growing trout selected by grading operations continued to grow faster after planting in Pond No. 2. While the difference between the average length of the runts and selects planted in ponds 4 and 2 respectively, was not very great, it undoubtedly played an important part

in the growth rates obtained although it is questionable whether or not it had much effect on the survival rates.

As noted above, although every effort was made to clean all large trout out of the ponds before planting fingerlings each season, in 1936 seven large Loch Leven were found in the ponds after draining. In spite of the presence of these large fish, the percentage of survival was greater than in previous years. These fish were killed and the stomach contents examined. One small trout was found in one fish. All of the other fish contained only shrimp. This might show than a few large fish present in a pond of small fish are not very harmful when there is an abundance of natural food present. On the other hand, failure to remove large trout in preparation for stocking usually serves but to furnish these big fish with a diet of nice, small, fresh trout. One such sportsmen's club pond was stocked with over 40,000 small Loch Leven and produced less than a one percent return. Failure to remove the big fish in the instance resulted in almost total loss of planted fingerlings.

One factor of major importance in relation to growth rates was the amount of natural foods present in the ponds. Pond No. 1 was the richest in natural foods of all the ponds. As noted above, watercress beds usually grew in dense masses in this pond and contained huge numbers of shrimp. The cress beds became progressively less dense with sparser, more scattered growths in Ponds 2, 3, and 4. In Pond 4 only scattered clumps occurred. While no quantitative food samples were taken to prove it, general observations showed natural foods to become progressively less abundant in the lower ponds. However, during summer operations, aquatic folds always seemed available in such quantities as to be far in excess of the needs of the fish planted.

Factors Contributing to Low Survival Rates

Since the start of operations at Hot Creek in 1932 we have had to contend with bird and other predators from time to time. Night and great blue herons, osprey, bitterns, grebes, gulls, snakes, and leeches are frequently seen about the ponds.

During 1932 and 1933, leeches which are quite abundant in the spring runs, accounted for a considerable loss of fish. In the first year's operation about 50% of the dead trout found in the runs showed leech marks. Young trout could often be seen swimming about with leeches attached to them. These are of large size, running from 1 to 2 inches long, and were determined as Helobdella stagnalis. Subsequent to 1933 very few leeches have been noted in the ponds and but few dead trout picked up in the ponds showed leech marks on them.

Great blue herons have probably caused severer losses than any other predators. Young fish, as noted elsewhere here, are extremely abundant in all the runs and these birds fed for the most part at points distant from the living quarters where they would not be disturbed. However, during the first over winter operation of the ponds in 1934-35, great blue herons were seen to feed consistently in Pond No. 2. As shown above this pond gave the lowest survival rate of any; 6.24%. Consistent gunning for them gave some aid but these birds soon become familiar with the technique involved and were extremely difficult to control. Apropos of the discussion in the P.F.C. on bird predators, it is most difficult to prevent depredations by great blue herons. These birds really become postgraduates in the art of securing a square meal of trout without getting caught at it. In 1936, there was very little trouble from birds until the last three weeks of operation, when great blue heron and bitterns

visited the ponds regularly. While it is impossible to draw any very definie conclusions as to the reasons for the varying survival rates obtained from year to year, the writers believe that fewer predator birds and leeches in 1936 largely account for the much higher survival obtained in this year.

The following is the list of birds shot at the Hot Creek Ponds in the summer of 1936 with the foods that were found in their stomachs.

6 Gulls - 4 stomachs empty; 2 contained suckers
5 Bitterns- 1 had eaten 7 small trout from ponds and 1 contained 1 small trout from the ponds. The balance of the stomach contents was made up of aquatic insects and shrimp.

One of the greatest difficulties in operating the ponds over the winter was snow conditions. At an elevation of 7,000 feet on the high inland plateau on which the ponds are located, very severe winter storms occur from time to time accompanied by high winds which blow snow into the ponds piling it up in large drifts. These in turn would break off into the ponds smothering fish in considerable numbers. By actual count over 200 dead fish were found under a drift in Pond No. 1 the winter of 1935. Naturally the warm spring water melted ordinary amounts as it fell into the ponds. However when huge quantities were drifted in by the wind, the water became choked with floating masses of wet snow and the temperature of the water was lowered close to the freezing point. In addition snow often clogged the screens making it difficult to keep the spillways flowing. Undoubtedly snow falling into the ponds and cooling the water accounted in part at least, for the smaller average monthly growth rates obtained in 1934-35.

At high elevations in the western United States where cold summer water temperatures prevail it may prove feasible to rear considerable numbers of trout at low cost on natural foods to assist in restocking streams and lakes. In many eastern areas at low elevations excessive summer temperatures often prevail which would tend to make this method hazardous at best unless springs of low temperature are available that could be used. The results presented here from four years operation of the Hot Creek Ponds lead the writers to believe a great deal of good work can be accomplished in rearing trout to good planting size by this method where proper water and food conditions exist and where such natural rearing ponds could be properly constructed and operated.

In conclusion, the principal requirements for rearing trout in natural rearing ponds on natural foods alone might be listed as follows:

1. Adequate water supply of proper growing temperature
2. Adequate food supply
3. Protection from seasonal floods
4. Absolutely tight screens to prevent large fish from getting into the ponds as well as to prevent stocked fish from getting out.

FOUNDERS OF FISH CULTURE

RICHARD NETTLE, FIRST CANADIAN FISH CULTURIST

By J. A. Rodd, Ottawa, Ontario.

THE FIRST Canadian fish culturist was the late Richard Nettle of Quebec and Ottawa, who died in Ottawa in lower Canada (Quebec) in 1857, and that year, in answer to a written application therefor, he was given permission to resort to artificial propagation as a means of restoring the salmon fisheries to their former value. His official report for 1857 states that "the spawn boxes will contain about 8,000 ova and portable boxes might be made to contain about 6,000 more within the pond or tank, and the large pond will contain about 10,000 young fish."

The water supply was obtained from the aqueduct from the St. Charles River and the eggs were hatched on gravel in wooden boxes lined with lead or zinc. The first experiments were with trout eggs obtained in the Jacques Cartier River and Lac Beauport, Que., and the resultant fry were reared and fed on boiled liver (pulverized) and small worms from the tan pitts until the fall of 1858 when "some of them were from 3½ to 4 inches in length and almost as broad as they were long".

In 1858 the 'ovarium' was stocked with salmon eggs (from 7,000 to 8,000) obtained from two pairs of salmon taken in the Jacques Cartier River. The report for that year states "that his success was all that could be hoped for and at least 70 percent of the eggs became young fish".

In one of his reports Mr. Nettle describes the performing of the Caesarean operation on some salmon eggs, the shells of which had hardened "by piercing the outer shell with a sharp pointed needle, taking care not to puncture any vital spot." He also reports that when collecting salmon eggs from the Jacques Cartier River in 859, he caught a trout that was following the salmon and feeding on their eggs. The trout was opened and from 300 to 400 eggs were carefully turned into a tub containing salmon milt: that a large proportion of the eggs were injured, but the remainder were placed in a separate box in the ovarium and in due course hatched and the fry were distributed in the St. Charles River.

Mr. Nettle's operations were continued into the early sixties.

J. A. Rodd
Ottawa, Ontario.

COMMENTS FROM OUR READERS

A NEW CIRCULAR REARING POND

THE DIVISION of Fish Culture has developed an improved type of circular rearing pond. It has been found by experience that a pond 25 feet in diameter meets the requirements of the average trout station much better than larger or smaller ponds of this type.

This latest type of pond is constructed for a depth of water 12 inches around the outer margin and 24 inches at the center. It has been found that this slope makes the pond much easier to work so far as cleaning and removing the fish is concerned. The gradient is sufficient to cause the debris and sediment on the bottom of the pond to be carried to the outlet by the current.

This type of pond does not have a center outlet. It does, however, have a trench 24 inches wide leading from the center of the pond at which point it is 3 inches deep. The floor of the trench has a drop of 3 inches to the outlet at the side of the pond. The point where the trench passes through the side of the pond has an opening 18 inches high and 24 inches wide. This connects with the discharge basin on the side of the pond which is approximately 24 inches square. It contains 1-½-inch slots for the screen and also similar slots for temporary damboards which are used when necessary to draw down the pond or control the water level. Under normal operating conditions the damboards are not used.

The overflow passes out through a 4 inch standpipe which is screwed hand-tight into an ell in the bottom of the catch basin. The height of this pipe establishes the water level in the pond. Around this pipe is placed a piece of 6 inch galvanized iron downspouting. It is approximately 2 inches higher than the water level and is open at the top. The bottom is supported by 3 legs 1 inch above the floor of the catch basin. The use of this pipe causes the water to be drawn from the bottom of the pond. By establishing a strong current on the bottom of the pond, most of the debris is carried out through the trench and through the outlet pipe.

The main water supply for the pond enters through a pipe with a double adjustable ell at the top and a flat nozzle causing a spray effect. In addition to this a further water supply through a ¾ inch or 1 inch pipe is injected at the bottom of the pond along the outside margin. This enters the pond through a tapering nozzle reduced from ¾ inch to ½ inch.

Under ordinary operating conditions both water supplies are frequently used. However, when it is necessary to clean the pond the upper supply is cut off and the bottom supply alone is used. The pond is drawn down by the removal of the 4 inch

outlet pipe until the water level along the outer margin is approximately 1 inch deep. The action of the bottom jet and the scurrying of the fish cause the pond bottom to be swept clean. The attendant in control of the 4 inch outlet pipe regulates the out-flow of water so that the suction will not be too great. When necessary to remove the fish from the pond, temporary damboards are inserted and the pond drawn down until all the fish are carried into the trench. It is then a very easy matter to remove the fish with a small hand dipnet.

The latest station to use these ponds is the Walhalla, S. C., station, at which point 42 such ponds have been constructed. They are more economical to operate than the older type with the center outlet. However, the cost of construction is somewhat higher. It is the experience of this Division that they are more efficient than the center outlet type and have better control, both in cleaning the pond and in removing the fish.

The pond as above described with an 8 inch reinforced side wall and 4 inch bottom requires approximately 16.7 cu. yds. of concrete of a 1:2:4 mixture. The cost of the pond varies in accordance with the locality in which it is constructed. On the average, it is estimated that the cost is $250 for each pond.

G. C. Leach,
Chief, Division of Fish Culture.
U. S. Bureau of Fisheries

LACK OF FOOD DRIVES TROUT FROM STREAMS

IN THE FEBRUARY issue of the "Progressive Fish Culturist" there was an article entitled "Need of Improvement in Stocking Methods" by Charles L. Fuqua. Although I agree with Mr. Fuqua on some points there are others on which I do not. I think any man given the proper instructions can stock a stream correctly. The whole trouble, in my opinion, is the lack of trout food in these streams when they are stocked.

I have planted a great many millions of trout in streams and private preserves and I have found that when there is a lack of food trout will wander away and go into large bodies of water and will not return to the stream where they were planted.

You take hatchery raised trout that have had all the food that they needed and turn them loose into one of our streams where there is scarcely any food they will keep moving further and further away from the planting ground until they find a large body of water where they can find some food.

Some years ago I gave the food supply of our natural streams a great deal of study. I tried fresh water shrimp but found that they would live in only about 5 percent of our streams so I had to give up the question of shrimp. Then I tried soft shelled snails. This was not satisfactory, so I started breeding Ascellus (sow bugs) and they are a wonderful trout and bass food for natural streams and ponds.

I raise and distribute millions of them every year and I find that anywhere the Ascellus are you will always find plenty of fish and good fishing.

It is just as essential to have a food supply in our streams as it is to have trout. If you do not have food you will not have any fishing. If the Ascellus are planted fifteen thousand to the mile of stream or acre of pond they will breed fast enough to keep themselves restocked and you will find that the question of planting fish is a small part of the work.

Some years ago I planted one of our streams with brook trout. This stream had but very little natural food in it. I watched this stream very closely to see the results. In eighteen days after planting the greatest part of the fish was in deep holes 7½ miles from the planting ground on their way downstream. I think this is proof enough of what becomes of the most of the trout in our streams. Now this same stream has wonderful fishing in it as we keep it well stocked with Ascellus and we find that the fish will not leave it.

I do think that every stream should be investigated thoroughly to determine if there is food enough in it for the trout before they are planted. When this is done we will find that our fishing problems have been solved.

A. A. Townsend,
Napanoch, N. Y.

OPERATIONS AT TULSA'S HATCHERY IN 1936

Editor, THE PROGRESSIVE FISH CULTURIST.

I AM INCLOSING a brief report of the propagation and distribution of fish by the Tulsa Municipal Hatchery for season past.

This concludes the sixth year of our operations, and there have been planted in Tulsa's 2,500 acres of municipal waters, 2,270,000 fingerling fish. This is approximately nine hundred fish per acre.

Most of these fish have been planted in Spavinaw lake, which is an artificial reservoir of 1,800 acres. This lake is located in the Ozarks and fed by Spavinaw creek, a spring fed stream. Due to the wild nature of the watershed Spavinaw lake is seldom turbid. The lake contains several hundred acres of shallow water suitable for spawning. The rest of the lake is from twenty to sixty feet deep with steep sides a typical mountain valley basin.

Fishing has always been considered good at Spavinaw. However, many anglers express disappointment regarding the expected increase of the catch after each seasons stocking. The facts are that the actual catch has not increased to any great extent. We do feel that we have maintained the supply, and provided excellent angling, in the fact of several adverse factors. There is a steady increase of the number of

anglers. Carp are increasing at an alarming rate. Yellow Perch were introduced about seven years ago, and areas formerly occupied by crappie are now controlled by perch. We have no closed season during spawning time in the State of Oklahoma.

Considering these factors, the writer is convinced that our propagation program is worth while. We do believe also that good fishing on Spavinaw lake could be maintained by proper management, and control of predaceous species. Such a program coupled with our propagation work is our objective for the future.

We believe it is fundamentally necessary to know what is being taken from the lake. How many anglers use the reservoir, their catch, species, and other matters such as can be learned only through the creel census. We have recently attempted the creel census plan, and hope to win the confidence and cooperation of anglers.

We have contracted with several commercial fisherman to remove carp, suckers, and red-horse from Spavinaw lake. So far their efforts have met with little success. The configuration of the basin is such as makes netting difficult. The shallow areas are covered with stumps and the large area of deep water is rugged and rough. Will someone offer advice on means of removing these predators?

We hope to have a closed season on bass and crappie fishing in Oklahoma, but sentiment seems to be against it. The City of Tulsa has authority to close the lake to fishing at any time. But, with the rest of the State open would we lose our patrons who have cottages, and boats, and equipment at Spavinaw? The revenue is heavy during early spring. Out-of-state anglers take advantage of our fishing. The revenue received supports our program. If we can maintain good angling by artificial propagation in all City owned waters, should we deny our citizens the privilege of fishing when the "spring fever" is running high?

Forage fish are plentiful in our lake and the reservoirs in Mohawk Park. Several species of chubs inhabit the creek above the lake, and dace minnows are common. The predominating forage species is the hickory shad, (Dorosoma cepedianum). The hickory shad spawns all through the summer in Spavinaw lake. Great schools of shad fry may be seem as late as September. At times the entire surface of the lake seems to be alive with tiny shad. Bass, crappie, bluegill, and channel catfish can be seen scooping them up by the mouthful. Bass taken from Spavinaw are always fat. At twelve inches long, which is our minimum size limit, a weight of one pound is common. Many bass weighing eight and nine pounds have been taken that measure but twenty-three inches in length.

These shad also enter the reservoirs in Mohawk Park through the gravity conduit from Spavinaw. The same condition exists here in regard to the healthy growth of game fish. In fact food is so plentiful that anglers complain about the bass playing with their bait and refusing to swallow it. Many fishermen claim they are so full of shad that there is no room for bait. This situation has been somewhat modified we hope due to an extraordinary flight of fish ducks. The ducks have made camp on the reservoirs, and the shad are fast disappearing. We accept this as a demonstration of Mother Nature maintaining a biological balance.

Not wishing to add fuel to the flames, but merely as a passing thought: Cranes, herons, bitterns, and gulls have also found the supply of shad in our lakes. They stop with us at the hatchery quite frequently. We have wondered about the friendliness of their visits, and a few stomachs were examined this season. We have not found evidence of game fish in the contents. Crayfish, and tad-poles are the rule. It may be that after stuffing on shad the birds come to the hatchery for crayfish as dessert.

A. D. Aldrich, Supt.,
Tulsa Municipal Fisheries.

TULSA MUNICIPAL FISHERIES

PRODUCTION AND DISTRIBUTION

1936

	Disposition			
Species	Spavinaw	Sequoyah	Lagoons	Total
SM Black bass	2,000			2,000
LM Black bass	81,000	5,000	8,000	96,000
Crappie	49,000		14,000	63,000
Bream	50,000		65,000	115,000
Bullheads			15,000	15,000
Channel catfish	10,000		1,000	11,000
Warmouth bass	15,000		10,000	25,000
	207,000	5,000	113,000	325,000
Channel cat from state hatcheries to Spavinaw				4,000
Crappie from U. S. Bureau of Fisheries to Mohawk				35,000
TOTAL NUMBER OF FISH PLANTED				364,000

Following table shows size of fish planted

	2 inches	3½ inches	4 inches	5 inches	8 inches
Black bass		13,000	53,000	8,000	22,000
Crappie		63,000			
Bream	115,000				
Bullheads				15,000	
Channel catfish				11,000	
Warmouth bass	25,000				

CLUB TRIBUTE TO CHARLES O. HAYFORD

KENNETH B. LOCKWOOD, Fishing Editor of the Newark Evening News, contributes the following under date of May 26:

"It has occurred to me that readers of THE PROGRESSIVE FISH CULTURIST might be interested to know of C. O. Hayford's twenty-fifth anniversary as superintendent of the State Hatchery at Hackettstown, N. J.--its first and only superintendent. Maybe they would be interested, also, in knowing what representative sportsmen think about him, as indicated in the enclosed clipping.

"The club referred to is the oldest of its type in the State and the only one functioning when Charlie arrived here from his home at Oquossoc, Me., as the result of a request from the late Ernest Napier, then President of our Fish and Game Commission, to the Chairman of the Maine Commission, to send him here to aid in locating a site for the proposed hatchery."

The clipping from Mr. Lockwood's column from the Newark Evening News of the same date reads in part as follows:

"The Newark Bait and Fly Casting Club last night paid its tribute to Charles O. Hayford, who on Monday (May 24) rounded out a quarter of a century of outstanding service as superintendent of the State Hatchery at Hackettstown.

"The club's recognition of Charlie's achievements took the form of a testimonial dinner, marked by a capacity attendance, and the presentation of a platinum wrist watch. To him, also, was presented a watch to be delivered to Mrs. Hayford.

"In addition to expressing his own sentiments, Commissioner Spinks, who is the oldest member of the board in point of service, voiced what he felt would have been said about the guest of honor by President George C. Warren, Jr., who was unable to attend because of the death of his mother. All hands expressed the hope Charlie would remain at least 25 years more as superintendent of the hatchery."

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REVIEWS

THE PHYSIOLOGY OF FRESHWATER FISH OF CENTRAL EUROPE

Die Physiologie der Susswasserfische Mitteleuropas by Wilhelm Wunder. (Reprinted from Handbuch der Binnenfischerei Mitteleuropas Band II B.) E. Schweizerbart'sche Verlagsbuchhandlung. Stuttgart 1936. 340 pp. 213 illustrations. 9 dark plates and 1 colored plate.

THE VOLUMINOUS literature on fish physiology that has accumulated since Winterstein's "Handbuch der Vergleichende Physiologie" has been brought up to date and unfolded in scholarly fashion by an eminent European comparative physiologist, Dr. Wilhelm Wunder.

To the reader of German is opened a learned, well-illustrated monograph on the function of the various organs of many common European fish. Some of these fish are also common in America and for this reason the book should prove valuable to our fish culturists and ichthyologists.

A careful review of Dr. Wunder's discussion impresses the American fish culturist with the magnitude of absolute information that exists in the foreign literature on the physiology of fish. There is left no doubt in the reader's mind that these scientists lead the world in research on this subject. In spite of the comparative definiteness with which some topics are discussed the author leaves his topic open to more illuminating discoveries that may alter the present beliefs or explanations of various physiologic functions in fish.

On many debatable questions of a fish's ability to see, hear and taste, the author generally favors the vonFrisch school. It was to this Dean of European fish physiologists that the monograph was dedicated.

The author derides the earlier physiologists who continually insisted that a fish could not hear because it had no cochlea, and could not learn because gray matter was absent from its brain. He comments, "Because man is not able to smell in fluids with his air adapted nose (Luftnase) is no argument for a lack of a sense of smell in aquatic animals." It was such reasoning among the older scientists however, which stimulated the research that has solved these questions.

After epitomizing the literature on hearing in fish Dr. Wunder concludes the discussion with the experiments of Stetter and von Frisch who maintained to have shown that some fish not only hear but can differentiate pitch. A European fish, the Elrit, (Phoxinus laevis) was trained (by reward and punishment) to take food upon the sounding of a signal note. Blinded fish acquired the same facility. The training to the feeding note was remembered by this species 229 days after cessation of the tutoring period. This memory time varied with other species. These methods, supplemented

with delicate and ingenious surgical techniques on the labyrinth enabled these workers to establish the sense of hearing in the sacculus and lagena.

The literature on the disputed question of color vision also is brought up to date. The above workers on hearing, also were able to establish recently that fish could differentiate between colors. They were trained to take food from a red container, no matter where it was located in the aquarium, surrounded by other similar containers differently colored.

Dr. Wunder's review of the research on the physiology of the swimbladder is didactically thorough. The general concensus of opinion is that this organ functions chiefly as a hydrostatic, barometric pressure announcer and specific gravity control mechanism. Of interest to the fish culturist, who may not have read the original articles on the function of the swim bladder in young trout, is the observation that young trout after resorbing the egg sac must struggle to the surface to fill their swimbladder so that swimming may be more effortless. They perish if kept from reaching the surface. The same characteristic is true of carp.

Those fish which in adult life have no open passage between the esophagus and the air bladder (Physoclisti) must fill their swim bladder before it closes by embryological procedure. This happens, as a rule, 2 or 3 days after hatching. In these fish the red gland, a specal gas secreting gland, controls the pressure and gas percentage relationship of O2, CO2 and N in the bladder. The function of this gland is adequately discussed.

The fish pathologist as well as the physiologist may find interest in the chapter on blood and circulation where the effects of parastic infection producing anemia in fish is reviewed, in addition to the changes in blood corpuscle counts caused by various infections and other changes of diagnostic value.

The author alludes to Hesse's significant observations that fish have very small hearts in proportion to their body weight. The average fish has a heart that is 1% of the body weight, while in mammals it is 8% and in some birds 16%. This peculiarity makes the phenomenon of blood circulation very complicated. It means, according to some investigators, that fish must call upon auxilliary mechanisms to carry on efficient circulation. These workers found that there exists a continuous rhythmic pulsation of the body musculature which assists blood distribution. The heart itself must be augmented to affect an adequate venous return, a sort of sucking action which is achieved by a negative pressure in the pericardium by action of the surrounding musculature. The reviewed work of Bruning who explained the phenomenon of blood pressure is particularly outstanding.

Dr. Wunder quotes from Skramlik who has investigated the physiology of heart action in fish. Skramlik leads the field of recent workers in his contribution to the knowledge that the fish heart is controlled only by the vagus nerve and that when this is sectioned the heart possesses its own automaticity of a very different type from mammals. In mammals both the vagus and the sympathetic nerve exert a controling influence.

Many ingenious surgical techniques have been gathered by the author from the literature. These should be of assistance to the fish toxicologist who wishes to observe effects of pollutants on various physiologic functions of fish.

There is a lengthy review of the literature on the physiology of the skin or body coverings in general. Even the new field of endocrinology has contributed to the knowledge of fish behavior and is briefly discussed. Other chapters, profoundly presented, cover such subjects as metabolism, development, digestion and the central nervous system. There are 340 pages of up to date information on the how and why of fish and the function of their organs. The reviewer of this monograph recommends an early translation of this complete work so that it might be more accessable to American readers, for it is by far the most complete summary of its kind in the literature.

Arthur D. Hasler

ABSTRACT: INVESTIGATIONS ON THE ARTIFICIAL INSEMINATION AND HATCHING OF BROOK TROUT EGGS FROM DIFFERENT GROUPS OF BROOD FISH AND THEIR FURTHER DEVELOPMENT IN PONDS TO THE AGE OF ONE YEAR.

By Dr. Ing. Erhard Robert Wiesner
Zeitschrift fur Fishcherei, Bd 33, Heft 1, Jan. 1934, pp. 69--151.

THE LARGER FRY come from the larger eggs. The size of the eggs increases with the age of the mothers; it depends on the age, growth conditions and total number of the mothers. Apparently a relationship exists between the total numbers of eggs and the factors internal as well as external, affecting the growth of the mothers. The number of eggs per Kg. of body weight decreases with the age of the mothers (*). This applies also to the total weight of the eggs expressed as percent of body weight. The colour of the eggs is indicative of the nutritional status of the mothers. Losses during incubation increase with the age of the mothers and are specially high in the case of over-ripe eggs. The latter condition is also a contributory factor in malformations, twinning, yolksack disease, and undeveloped eggs.

The appearance of the fish at any age is an index of its economic potential. Differences in the rate of growth increase during the developmental period and are determined by internal and external factors. The progeny of six year old mothers grew most unevenly; variations in size exceeded that of the progeny from a mixed group of three year old fish. The absolute effect of space was not apparent in a pond having an area of 32sq. m. Overstocking inhibits growth, increases losses, and produces larger variations in size. At first fish increase in length more rapidly than in weight. This relationship is changed to some extent by liberal feeding. The most rapid growth occurs when temperatures and plankton-production are at a maximum, and lasts for twenty-eight days. The effect on growth of many factors is eliminated by artificial feeding. In ponds where fish depend on natural food to some extent, the flow of water should be greatly reduced. This condition, however, favours the existence of enemies. Shallow ponds are not desirable for artificial feeding.

Normal variations in pH and in total alkalinity are determined by the carbon dioxide content of the pond water. Rains cause abnormal variations in these values. The chemistry of spring waters is altered by atmospheric precipitation. The total alkalinity reaches a minimum during the summer. Products resulting from the decomposition of dead organisms and feed exert a beneficial effect upon the pond water.

* This apparently also applies to largemouth black bass-Abstractor.

A. H. Wiebe

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